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THE TOMATO PINWORM

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INTRODUCTION

The presence in the United States of the tomato pinworm (*Gnorimoschema lycopersicella* Busck), which has become a serious pest of tomatoes grown in the field or in greenhouses, was first detected in the Imperial Valley of California in 1922. Since that time it has been recorded, by various workers, from the following points in this country: California, counties of Imperial, San Diego, Orange, Riverside, San Bernardino, Los Angeles, Ventura, Kern, Tulare, and Stanislaus; New Mexico, Dona Ana County; Missouri, Buchanan County (St. Joseph); Florida, Manatee County (Bradenton) and Dade County (from Miami to Homestead); Mississippi, Harrison County (Gulfport and Long Beach); Virginia, Norfolk County (Norfolk); Delaware, New Castle County (Wilmington and northern part of this county); Pennsylvania, counties of Chester and Delaware (northern part of these two counties) and Lawrence County (New Castle).

Outside of the continental United States, according to the literature, the tomato pinworm occurs in Hawaii and in Haiti, Mexico, and Peru. Larvae of the pest have also been intercepted in tomatoes from the Bahamas, from Bermuda, and from Cuba.

In California, New Mexico, and Florida the tomato pinworm thus far has been primarily a pest of field-grown tomatoes, whereas in Mississippi and in the States farther north it has been present only as a pest of tomatoes and other host plants grown in greenhouses and in nearby fields.

ECONOMIC IMPORTANCE

Losses from pinworm injury have been heavy in California every year since the pinworm became established. A survey of representative fields in southern California in 1936 showed an average infesta-

tion of 28 percent, with a maximum infestation of 99 percent of the fruit in late fields. At Bradenton, Fla., in 1932, 100 percent of the fruit left on the vines at the close of the season had been attacked. Fruit injury to greenhouse tomatoes has been no less striking. In Pennsylvania infestations of from 50 to 100 percent have been common.

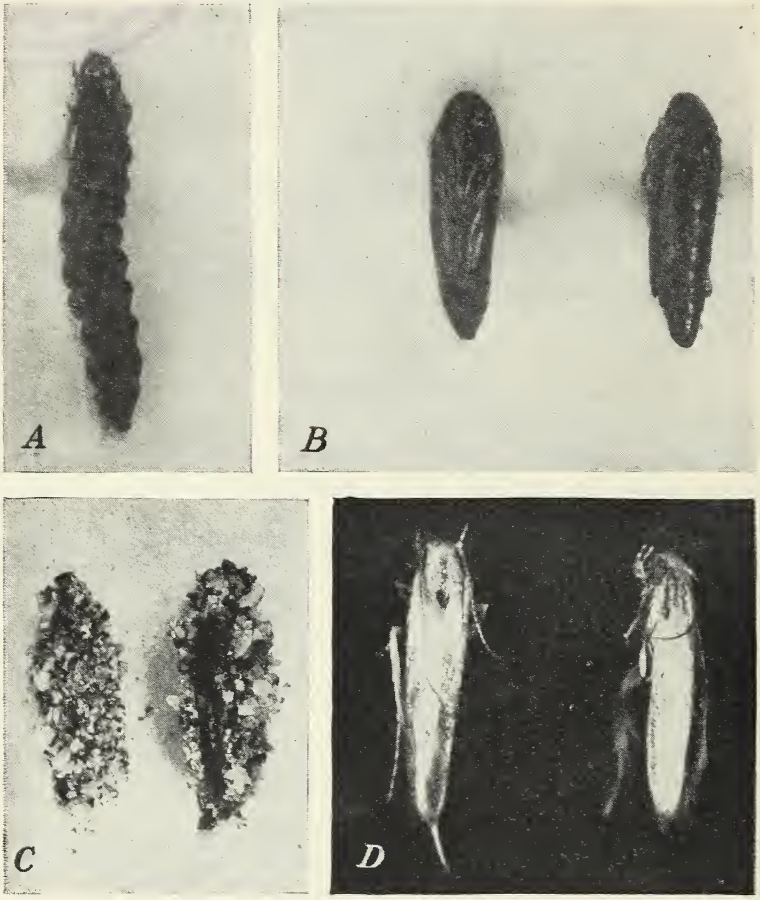

FIGURE 1.—Stages of the tomato pinworm: *A*, Larva; *B*, pupae; *C*, pupae in loosely woven cells mixed with soil particles; *D*, adults. ×6.

HOST PLANTS

Tomato and potato are the preferred host plants of the tomato pinworm, but it is occasionally found on eggplant, on horsenettle (*Solanum carolinense* L.) in Pennsylvania, and on a native nightshade (*S. umbelliferum* Esch.) in California.

GENERAL DESCRIPTION OF THE TOMATO PINWORM

The body of the partly grown larva is pale yellow with irregularly shaped purple spots. The head is dark brown. The fully

grown larva (fig. 1, *A*) is about one-fourth of an inch long, with a slender ash-gray body bearing dark purple spots; the head is light brown or yellow.

The pupa (fig. 1, *B*) is contained within a loosely woven cell (fig. 1, *C*) mixed with soil particles formed at or just underneath the soil surface. It is shuttle-shaped, varies from light green to light brown in color, and is about three-sixteenths of an inch long.

The adult (fig. 1, *D*) is a gray moth, about one-fourth of an inch long when the wings are folded.

CHARACTER OF INJURY

After hatching from the eggs, which are laid indiscriminately on the plants, pinworm larvae mine the leaves. The small pinworms form their mines by feeding only on the inner part of the leaf, leaving the upper and lower leaf surfaces intact. These mines (fig. 2, *A*) are of the serpentine type at first but are later widened to the blotch type (fig. 2, *C*). This feeding on the inner portion of the leaf causes the outer surfaces to appear transparent. When the larvae are about half grown, in the case of leaf feeding, they leave the mines to form leaf folds that act as shelters or retreats from which they continue to feed on the inner parts of the leaf (fig. 2, *B*, *C*, and *D*). This type of feeding causes large blotches adjacent to each leaf fold. A large number of leaves may thus be destroyed (fig. 3), but the injury to the plant from this source is not so important as is the damage by the larvae to the fruit.

Larvae that have mined the calyx lobes, and many of those from the leaf mines nearby, enter the fruit instead of folding the leaves. Usually the larvae enter the fruit beneath the calyx lobes or fruit stem, but in heavily infested fields about 50 percent of the fruit may have entrance holes in other places as well. These entrance holes, which resemble pinholes, have resulted in the common name of "pinworm" being applied to this insect (fig. 4). Larvae that enter the fruit beneath the stem penetrate to a depth ranging from one twenty-fifth to three-fourths of an inch. Many of the larvae in the fruit feed only in the core. This permits "coring" at the cannery to remove much of the damage caused by this pest. The total injury caused by the pinworm to each tomato fruit is not great, but its presence therein is objectionable, and it may cause untimely decay. In addition, the presence of this insect, or fragments thereof, in manufactured tomato products may cause the rejection or seizure of such contaminated products.

LIFE HISTORY AND SEASONAL DEVELOPMENT

As is common with other insects, the duration of the stages of the tomato pinworm, and its seasonal development, are dependent upon prevailing temperatures and other climatic influences.

The data shown in table 1 upon the average duration of the various stages were obtained in an outdoor insectary in Southern California, under temperature conditions ranging from near the threshold of development, at a mean temperature of approximately 50° F., during the winter months, to the highest summer temperatures, at a mean of approximately 80°.

TABLE 1.—*Duration of stages of the tomato pinworm, at various mean temperatures, Alhambra, Calif., Apr. 19, 1935, to Apr. 16, 1936*

Stage	Duration of period at mean temperature of—					
	50–55 °F.	56–60 °F.	61–65 °F.	66–70 °F.	71–75 °F.	76–80 °F.
	Days	*Days*	*Days*	*Days*	*Days*	*Days*
Egg period	20	11	9	7	6	5
Larval period	41	26	18	14	14	10
Prepupal and pupal period	39	(1)	18	13	11	11
Total, egg to adult	100		45	34	31	26
Adult period:						
Males	21	23	16	11	11	10
Females	25	25	11	14	(1)	7

[1] No complete records.

It will be noted that, under conditions approximating those prevailing in the field in southern California, the tomato pinworm is able to complete its life cycle from egg to adult in periods ranging from approximately 26 to 34 days during the summer season and that the rate of development is retarded greatly at lower temperatures. Records obtained in the greenhouse in California indicated that the duration of each of the stages was approximately the same, at a given temperature, as those obtained in the outdoor insectary. Thomas [1] reports that the duration of the life cycle in the greenhouse in Pennsylvania was from 5 to 6 weeks.

The ability of the insect to pass rapidly through its life stages under favorable conditions has resulted in the development of seven generations in one year on field-grown tomatoes in California. This complicates greatly the problem of combating the pest.

RELATION OF LOW TEMPERATURE TO SURVIVAL

Although the relation of low temperature to tomato pinworm survival has not been explored thoroughly, the information obtained thus far indicates that this insect is not able to survive normal winter weather outdoors in the more northern points where it has been found in this country. Thomas [2] reports that experiments during the winter of 1935–36 in Pennsylvania showed that infested leaves, kept outdoors for the period beginning early in November 1935, and brought indoors during January 1936, produced many living moths within 2 weeks, while those brought indoors on March 1, 1936, after some weeks of very severe, near-zero weather, did not produce a single living moth or other stage of the insect. The same author reports,[3] however, that studies had indicated that the tomato pinworm had survived the mild winter of 1936–37 outdoors in Chester County, Pa.

Field observations in southern California have demonstrated that the insect is able to lay eggs and develop during the winter season when the temperatures are high enough to permit the survival and

[1] THOMAS, C. A. STATUS OF THE TOMATO PINWORM GNORIMOSCHEMA LYCOPERSICELLA BUSCK IN PENNSYLVANIA. Jour. Econ. Ent. 29 : 313–317. 1936.

[2] THOMAS, C. A. THE TOMATO PINWORM. Pa. Agr. Expt. Sta. Bull. 337, 15 pp., illus. 1936.

[3] THOMAS, C. A. U. S. Dept. Agr., Bur. Ent. and Plant Quarantine, Insect Pest Survey Bull. 17 (2) : 55. 1937. [Mimeographed.]

growth of the tomato plant. During the winter of 1935–36 tomato pinworm infestations were found in abandoned fields where a few green plants were present. Observations in March 1937 disclosed

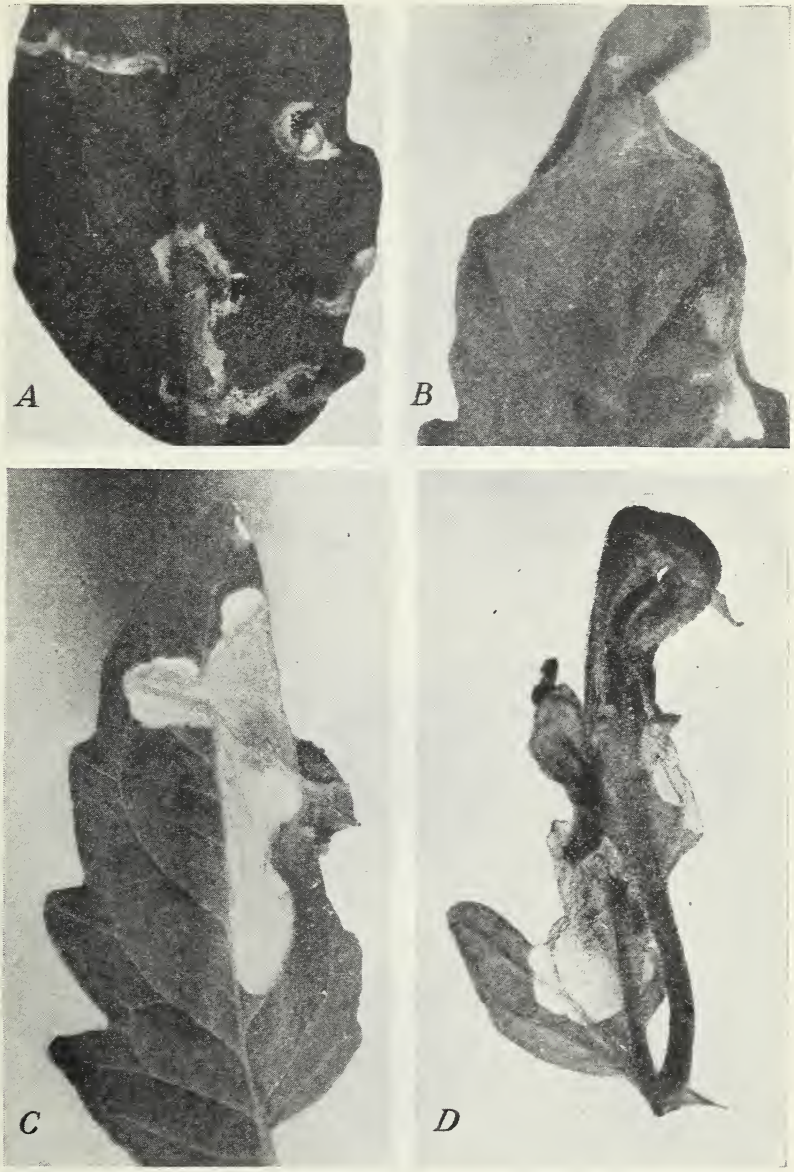

FIGURE 2.—Work of the tomato pinworm: *A*, Mines made by larvae in a tomato leaf (×6); *B*, typical appearance of a leaf fold in a tomato leaf made by a larva (×6); *C*, leaf fold caused by a larva, showing typical transparent leaf blotch or mine (×5); *D*, pinworm injury to tomato leaves in an advanced stage of development (×3).

that the insect had survived the winter in large numbers even though the longest period of low temperatures on record had occurred in this territory during the preceding January, including a minimum of

22° F., and a total of 17 nights during which the temperature at Alhambra fell below freezing. In general, it may be stated that in the southern California territory the development of the pinworm

FIGURE 3.—Top of a small tomato plant showing leaf folding caused by tomato pinworm larvae (approximately three-fourths natural size).

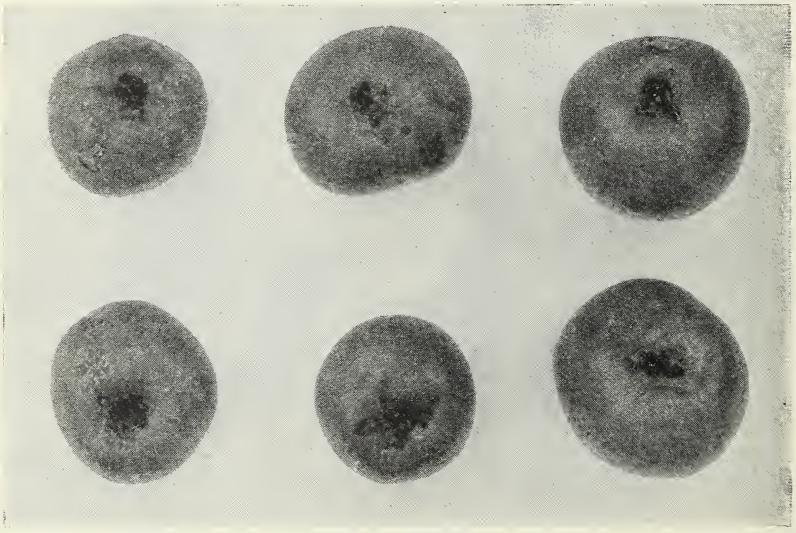

FIGURE 4.—Typical appearance of tomato fruits infested with tomato pinworm larvae. Injury of this character makes the affected fruit unfit for market. (Approximately two-fifths natural size.)

is retarded greatly by normal late fall and winter temperatures and may cease completely, except for the survival of pupae on or in the soil and of moths in protected situations.

CONTROL BY CULTURAL PRACTICES IN THE FIELD

The most important practice contributing to pinworm development and survival in the field, as typified by conditions in California, is the manner of handling tomato vines after the marketable fruit has been removed. These vines, which are usually heavily infested by pinworm larvae in all stages of development, still carry a large number of infested fruits. Old fields are often left standing after the last picking in the fall, and many of the plants may continue in various conditions of growth. As long as green vines and fresh fruit remain in such fields the pinworm continues to multiply. If low temperatures during the winter kill the plants, the pinworms that pupate in the soil are usually able to span the remaining period in large numbers to emerge during the early stages of the new tomato crop.

In some cases, if the soil on which tomatoes have been grown is needed for a winter crop, some of the growers follow the highly undesirable practice of cutting the vines and piling them at the edge of the field or on adjacent waste land. Pinworms, as they mature, enter the soil beneath these piles, and many immature ones are able to complete development in the fruit left on the vines. Records of moth emergence from plant piles of this type show that under these conditions the period of pinworm survival in winter is extended to about 45 days, constituting a prolongation of 87 percent, compared to the duration of winter survival in the bare soil. Survival of the tomato pinworm during the winter is also increased if old vines are left growing in the field, as compared with fields in which the vines have been removed.

As a result of these observations, a program of sanitation is recommended as the first and most important step toward pinworm control. This program should include the destruction of old tomato vines and the fruit they bear as soon as the marketable fruit has been removed. The quickest and best method of doing this is that of disking the field, thus cutting up the plants while they are green, followed by plowing. If the plants are to be cut and piled they should be arranged in small piles or windrows within the field where they were grown, and after becoming dry they should be burned. This clean-up should also include any eggplant, horsenettle, or nightshade plants that may be present in the field or along the field borders.

Experiments have shown further that the pupation of the tomato pinworm occurs at or near the surface of the soil and that if the pupae are buried 3 or more inches in the soil they are killed. Consequently, plowing has been recommended as the next step following destruction of the old plants by disking or burning. Whether the old plants are piled and burned in the field where they grow or on unused land, the soil where the stacks have been should be plowed.

If old tomato vines and the fruit they bear have not been destroyed, as well as eggplant, horsenettle, and nightshade plants, then new tomato crops should not be started near old fields containing these plants or near areas where old plants have been piled.

CONTROL IN GREENHOUSES

In working with this insect in greenhouses in Pennsylvania, Thomas [4] recommends clean-up and other precautionary measures, such as the following:

1. The heating of infested greenhouses to as high a temperature as possible, immediately prior to the removal of the old infested plants of the fall crop, in order to stimulate the emergence of moths, followed by a heavy fumigation with hydrocyanic acid gas (using calcium cyanide or sodium cyanide at the rate of approximately 5 to 8 ounces of cyanide per 1,000 cubic feet of space), in order to kill the exposed moths, pupae, and other stages of the insect.
2. The removal and destruction of dead tomato plants from greenhouses which have been given the heating and fumigation treatment.
3. The digging up of the beds in the interval between crops. This procedure turns under many tomato pinworm pupae to a depth from which the resulting moths are unable to reach the soil surface.
4. The steam sterilization of the beds, when the necessary equipment and facilities are available, in order to kill such pupae as may be present on or in the soil.
5. The repetition of the heating and fumigation treatment in infested greenhouses several days before new tomato plants are set, in order to destroy such moths as may have emerged from the beds after the previous treatments. As long a period as possible should be allowed to elapse between the destruction of the old and the setting of new plants.
6. The use of noninfested plants for the new crop. If the seedlings are grown outdoors in the summer and early in the fall, the seedbed should be enclosed tightly and completely with a screening of muslin which has a small enough mesh to prevent the pinworm moths from gaining access to the plants and laying their eggs. If it is necessary to buy plants, they should be obtained from a grower who is located outside of the limits of the area known to be infested by the tomato pinworm, or at least from a grower who can guarantee that his plants are free from the insect.
7. A delay should occur in the planting of the fall crop in greenhouses until after the first heavy frost, if conditions will permit. Such frosts will kill the moths outdoors and thus remove this possible source of tomato pinworm infestation by moths which might otherwise gain entrance to the greenhouse.
8. A thorough and systematic examination should be made of the small plants in the greenhouse, at regular and frequent intervals, after they are set in the beds. If tomato pinworm mines are found in the leaves, such leaves should be removed immediately and destroyed.

STATUS OF INSECTICIDES AS A MEANS OF CONTROL

None of the insecticides tested against the tomato pinworm thus far have proved effective in controlling this pest under commercial conditions. Tests with an extensive series of materials are being continued in an attempt to discover or to develop insecticides which will be effective against the insect.

[4] THOMAS, C. A. See footnote 2.

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